BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 416 (July 2023)
Microprocessor and Embedded System Laboratory

Final Project Report

Section: B1 Group: 03

IOT Based Mine Environment & Worker's Safety Monitoring System

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"In signing this statement, We hereby certify that the work on this project is our own and that we have not copied the work of any other students (past or present), and cited all relevant sources while completing this project. We understand that if we fail to honor this agreement, We will each receive a score of ZERO for this project and be subject to failure of this course."

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1 Abstract

This abstract introduces an IoT-based solution designed to monitor mine workers' health and safety in real-time. The system integrates sensors for temperature, pressure, humidity, gas, pulse rate, and oxygen saturation, transmitting data through radio communication. An alarm system activates if any parameter exceeds set thresholds, ensuring timely interventions. This comprehensive framework aims to mitigate risks and safeguard mine workers' well-being in hazardous environments.

2 Introduction

The mining industry presents inherent risks to workers' health and safety, necessitating advanced monitoring systems to mitigate potential hazards. This project presents an IoT-based solution tailored for real-time monitoring of vital parameters to ensure the well-being of mine workers. The proposed system integrates various sensors and communication technologies to provide comprehensive monitoring and timely intervention in case of emergencies.

Key Features:

1. Real-Time Environmental Monitoring:

- Temperature, pressure, and humidity sensors are deployed throughout the mine to continuously monitor ambient conditions.
- Data collected from these sensors provide crucial insights into the working environment, enabling proactive measures to prevent heat-related illnesses, atmospheric changes, and other environmental risks.

2. Gas Monitoring:

- Real-time gas sensors are incorporated to detect the presence of hazardous gases such as methane, carbon monoxide, and hydrogen sulfide.
- Continuous monitoring helps in early detection of gas leaks or accumulation, reducing the risk of explosions and respiratory issues among workers.

3. Pulse Rate Tracking:

- Each worker is equipped with wearable devices capable of monitoring their pulse rate continuously.
- Deviations from normal pulse rates can indicate physical exertion, stress, or potential health issues, prompting timely intervention or rest breaks to prevent fatigue-related accidents.

4. Oxygen Saturation Monitoring:

- Wearable oximeters are utilized to monitor the oxygen saturation levels of workers in real-time.
- Low oxygen levels can signify inadequate ventilation or the presence of harmful gases, triggering alarms and ensuring prompt evacuation or rescue operations.

5. Radio Communication for Data Transmission:

- Data collected from saturation sensors and wearable devices are transmitted in real-time using radio communication protocols.
- This enables seamless communication between workers, supervisors, and central monitoring stations, facilitating rapid response to emergencies or abnormal situations.

6. Threshold-Based Alarm System:

- An alarm system is integrated into the monitoring infrastructure to activate in case any parameter exceeds predefined threshold values.
- Alarms prompt immediate action, including evacuation procedures, emergency response activation, or adjustment of working conditions to ensure worker safety.

The proposed IoT-based mine workers health and safety monitoring system offers a robust framework for ensuring the well-being of personnel in hazardous mining environments. By providing real-time monitoring of environmental conditions, gas levels, vital signs, and seamless communication capabilities, the system enhances safety protocols and enables swift responses to potential risks, ultimately safeguarding the health and lives of mine workers.

3 Design

3.1 Problem Formulation

3.1.1 Identification of Scope

- ❖ Within the scope of our project, we recognize the urgent necessity to ensure the health and safety of mine workers operating in hazardous environments.
- ❖ We identify the potential of IoT technology to revolutionize monitoring practices, providing real-time insights into workers' well-being and environmental conditions.

3.1.2 Literature Review

- ❖ Extensive literature research is conducted to understand existing safety monitoring systems in mining contexts.
- ❖ We delve into the latest advancements in IoT sensor technology and machine learning algorithms applicable to health and safety monitoring.

3.1.3 Formulation of Problem

- ❖ Our project entails the integration of IoT sensors into mine environments for continuous data collection.
- ❖ We formulate machine learning algorithms to process the collected data, enabling predictive analytics for proactive safety measures.

3.1.4 Analysis

- ➢ Data interpretation involves analyzing information gathered by IoT sensors, including temperature, gas levels, pulse rate, and oxygen saturation.
- ➢ Patterns and trends in the data are interpreted to anticipate potential risks to workers' health and safety.

- We analyze factors such as environmental conditions, physiological responses, and equipment reliability to develop comprehensive solutions.

- Mathematical principles are applied to develop algorithms for data analysis and predictive modeling.
- Insights from natural and engineering sciences inform the design and optimization of the IoT sensor network and machine learning models.

3.2 Design Method

Graphical Representation:

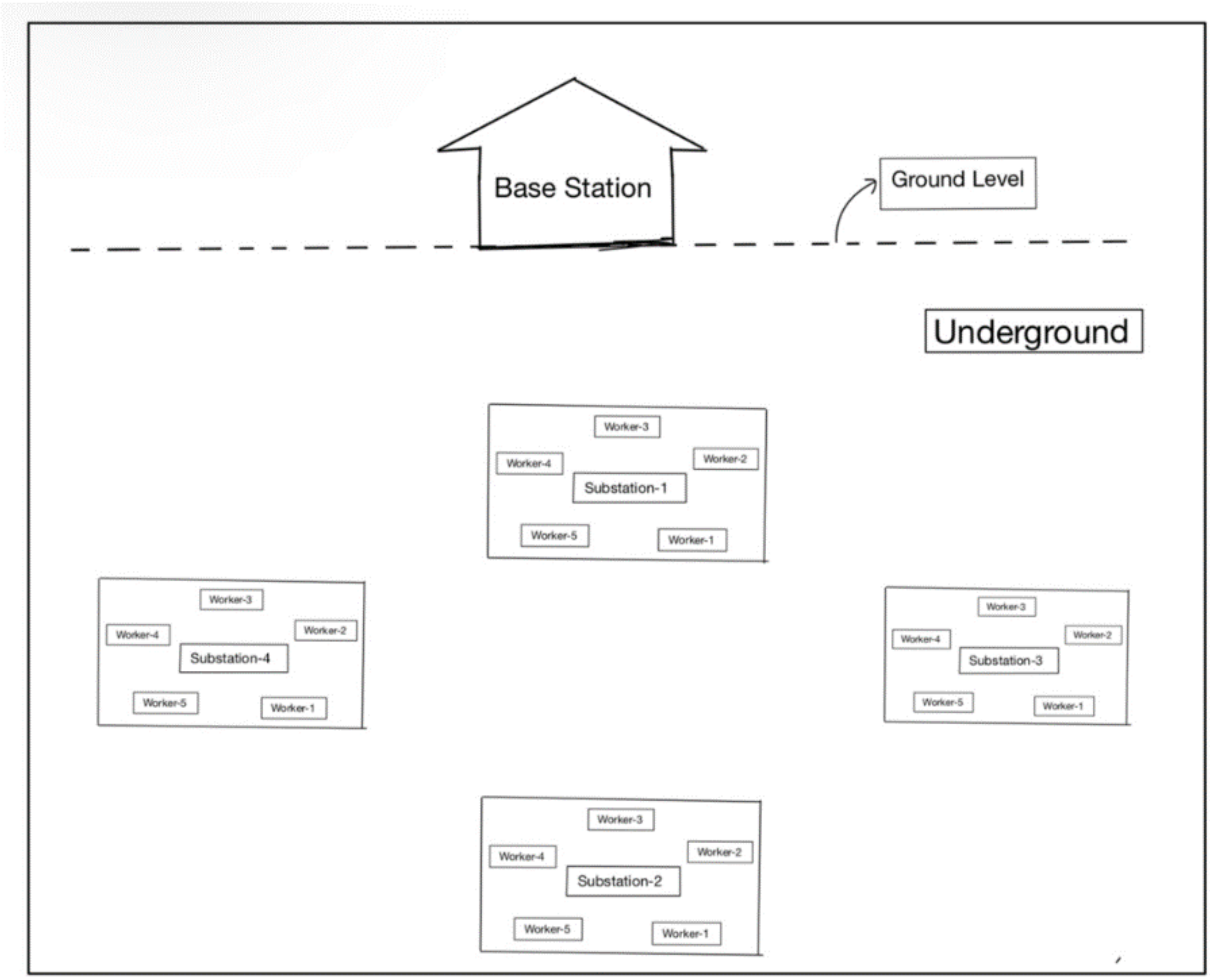


Figure-3.2.1: Modelling of the whole mine

Block Diagram:

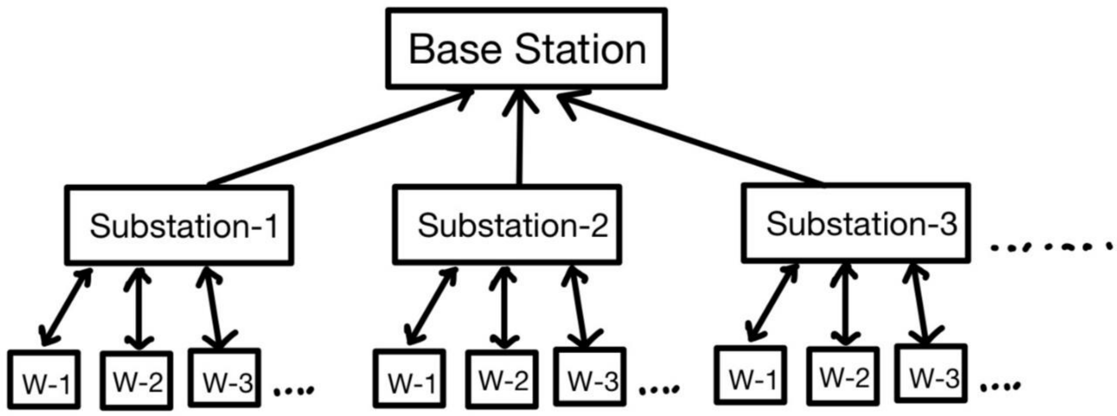


Figure-3.2.2: Communication method among stations

Workflow Diagram:

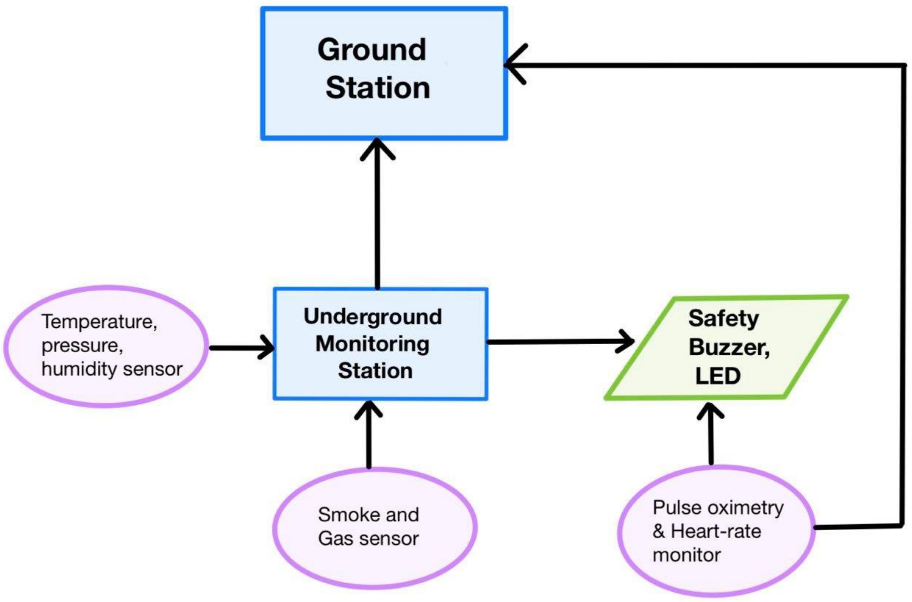


Figure-3.2.3: Workflow Diagram

3.3Circuit Diagrams

Base Station:

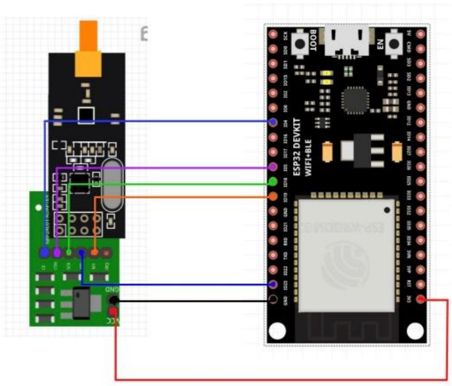


Figure-3.3.1: Base Station Circuit Diagram

Substation:

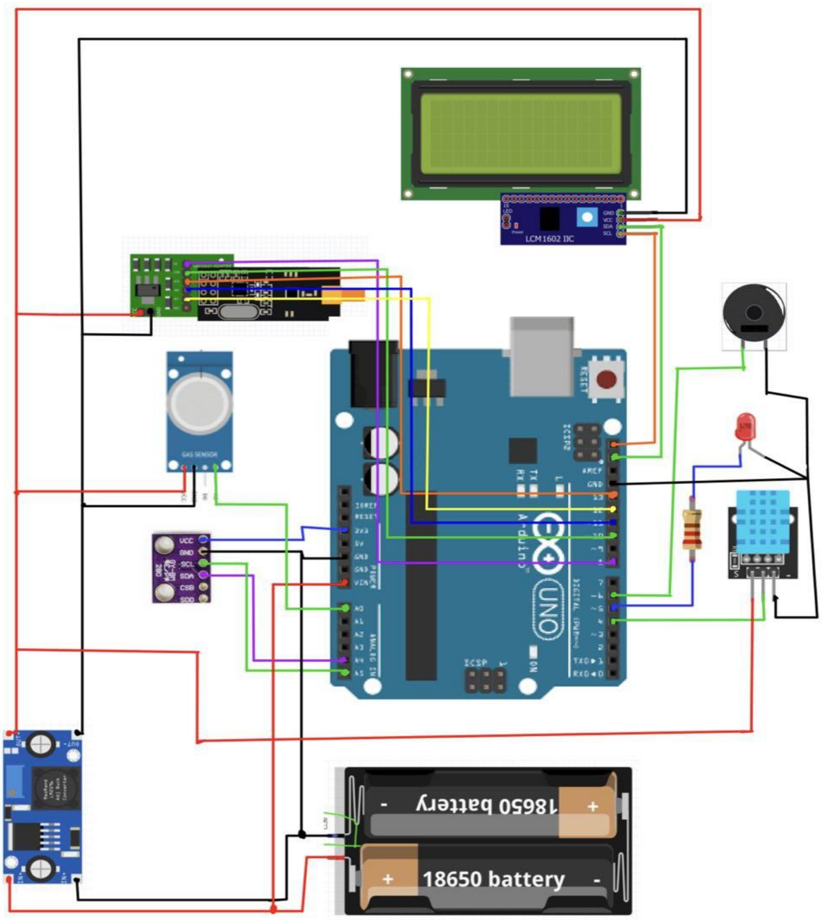


Figure-3.3.2: Base Station Circuit Diagram

Workers’ End:

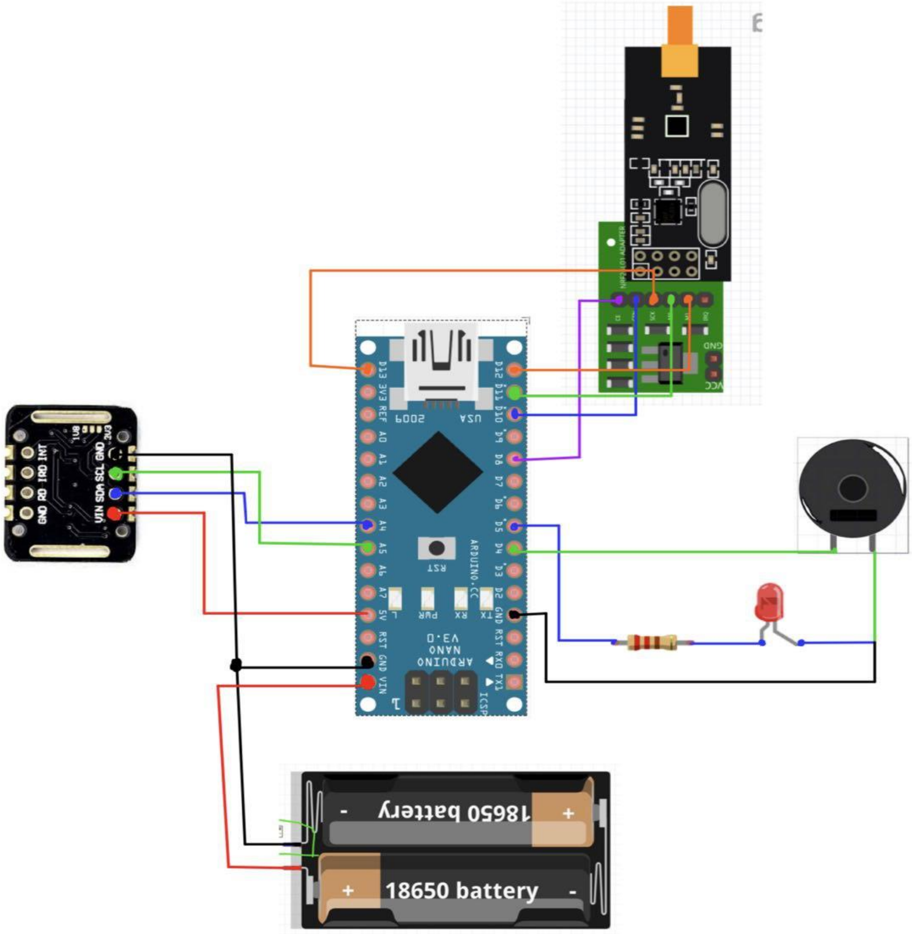


Figure-3.3.3: Worker Station Circuit Diagram

3.4 PCB Design

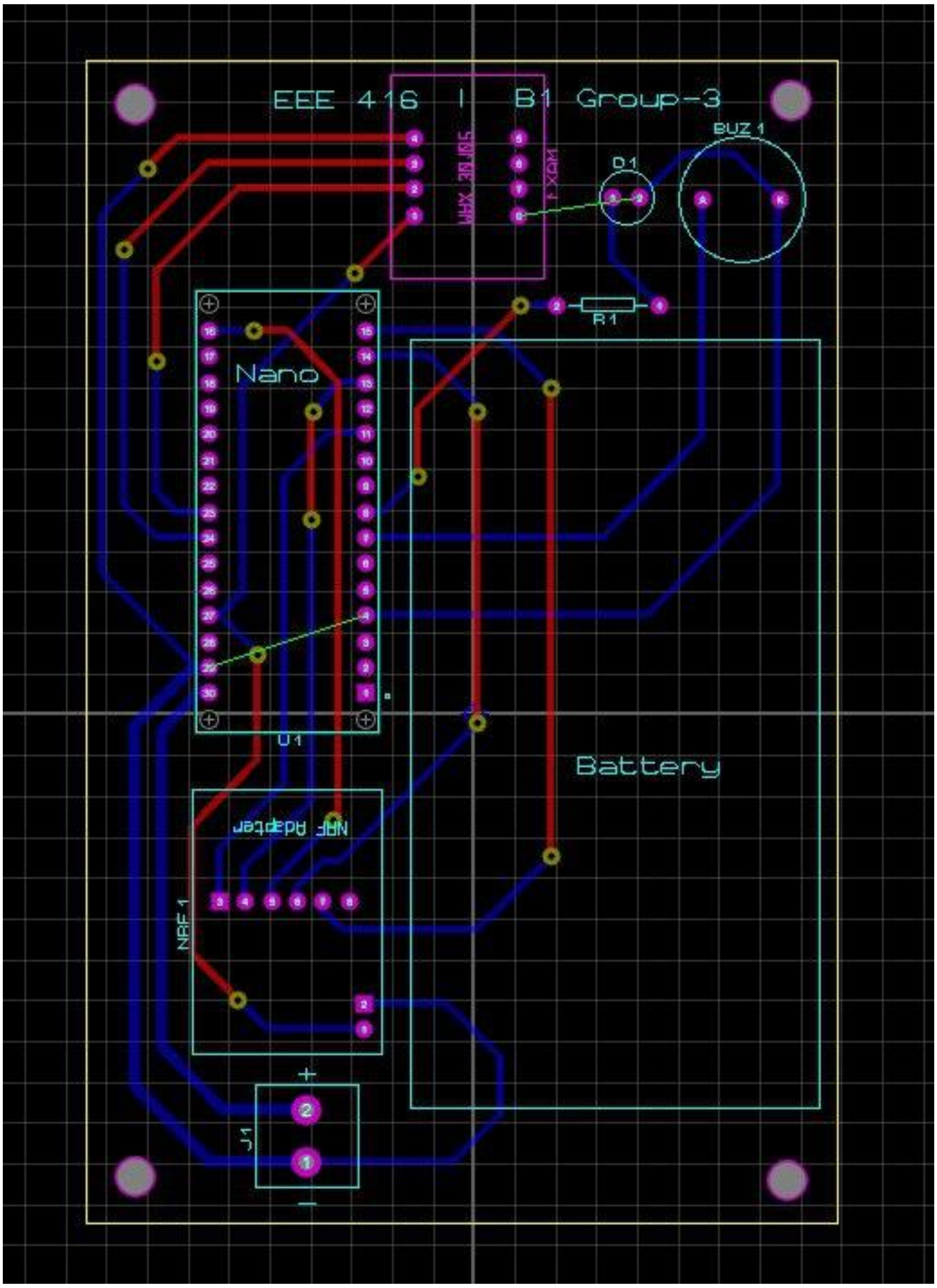


Figure-3.4.1: PCB layout

3.5 Full Source Code of Firmware

Base station:

```
#define BLYNK_TEMPLATE_ID "TMPL6V_jgnSrS"
#define BLYNK_TEMPLATE_NAME "Mine Environment"
#define BLYNK_AUTH_TOKEN
"oWpd4rYy9WIApLIFlYehiiHohppqm7Zc"

#define BLYNK_PRINT Serial
#include <WiFi.h>
#include <BlynkSimpleEsp32.h>

#include <RF24Network.h>
#include <RF24.h>
#include <SPI.h>

RF24 radio(4, 5);                  // nRF24L01 (CE,CSN)
RF24Network network(radio);       // Include the radio
in the network
const uint16_t base = 00;         // Address of this
node in Octal format ( 04,031, etc)
const uint16_t sub_station = 01;  // Address of the
other node in Octal format
const uint16_t worker = 011;      // edit

struct MyData {
  float temp;
  float pressure;
  float humidity;
  float gas;
};
float T, P, H, G;

MyData sensorValue;

char auth[] = BLYNK_AUTH_TOKEN;

char ssid[] = "POCO X2";  // type your wifi name
char pass[] = "Evan553-13";  // type your wifi password

BlynkTimer timer;

void sendSensor()
{
  // You can send any value at any time.
  // Please don't send more that 10 values per second.
  Blynk.virtualWrite(V0, T);
  Blynk.virtualWrite(V1, P);
  Blynk.virtualWrite(V2, H);
  Blynk.virtualWrite(V3, G);
  if (T > 35)
    Blynk.logEvent("temp_alert", "Temperature is above
35 degree!");
  if (H > 75)
    Blynk.logEvent("humidity_alert", "Humidity is more
than 75%!");
  if (G > 180)
    Blynk.logEvent("gas_alert", "Toxic gas in the
air!");
}
```

```
void setup() {
  Serial.begin(115200);
  SPI.begin();
  radio.begin();
  network.begin(90, base);  //(channel, node address)
  radio.setDataRate(RF24_2MBPS);
  Blynk.begin(auth, ssid, pass);
  timer.setInterval(100L, sendSensor);
}

void loop() {
  Blynk.run();
  timer.run();
  network.update();
  //===== Receiving =====//
  while (network.available()) {
    RF24NetworkHeader header;
    MyData sensorValue;
    network.read(header, &sensorValue,
sizeof(sensorValue));
    if (header.from_node == 011) {
      Blynk.logEvent("worker1_alert", "Worker1 in
danger!");
    }
    else {
      T = sensorValue.temp;


   P = sensorValue.pressure / 1000;
      H = sensorValue.humidity;
      G = sensorValue.gas;
    }
    Serial.print("Temp: ");
    Serial.println(T);
    Serial.print("Pres: ");
    Serial.println(P);
    Serial.print("Hum: ");
    Serial.println(H);
    Serial.print("Gas: ");
    Serial.println(G);
  }
  //delay(1000);
}
```

Sub station:

```
#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_BMP280.h>
#include <LiquidCrystal_I2C.h>
#include <dht.h>
#include <RF24Network.h>
#include <RF24.h>
#include <SPI.h>

// Set the LCD address to 0x27 for a 16 chars
and 2 line display
LiquidCrystal_I2C lcd(0x27, 20, 4);

//nrf
RF24 radio(8, 10);                // nRF24L01
(CE,CSN)
RF24Network network(radio);      // Include the
radio in the network
const uint16_t sub_station = 01;  // Address of
our node in Octal format (01, 02, etc)
const uint16_t base = 00;         // Address of
the other node (base station) in Octal format
const uint16_t worker = 011;
```

```
bmp.setSampling(Adafruit_BMP280::MODE_NORMAL,
                 Adafruit_BMP280::SAMPLING_X2,
                 Adafruit_BMP280::SAMPLING_X16,
                 Adafruit_BMP280::FILTER_X16,

Adafruit_BMP280::STANDBY_MS_500);


  SPI.begin();
  radio.begin();
  network.begin(90, sub_station); //(channel,
node address)
  radio.setDataRate(RF24_2MBPS);
}

void loop() {
  long lcd_start, lcd_end, dt;
  network.update();

  //===== Receiving =====//
  while ( network.available() ) {     // Is
there any incoming data?
    RF24NetworkHeader header3;
    char incomingData[32];
    network.read(header3, &incomingData,
sizeof(incomingData)); // Read the incoming data
```

```
#define LED 5
const int buzzer = 6;
#define dhtPin 4
int c = 0;
Adafruit_BMP280 bmp; // I2C
dht DHT;

struct MyData {
  float temp;
  float pressure;
  float hum;
  float gas;
};


void setup() {

  pinMode(LED, OUTPUT);
  pinMode(buzzer, OUTPUT);

  lcd.begin();
  lcd.backlight();

  Serial.begin(115200);

  while (!Serial)
    delay(100); // wait for native usb
  Serial.println(F("BMP280 and MQ135 test"));

  unsigned status;
  status = bmp.begin(0x76);
  if (!status) {
    Serial.println(F("Could not find a valid
BMP280 sensor, check wiring or "
                     "try a different
address!"));
    Serial.print("SensorID was: 0x");
    Serial.println(bmp.sensorID(), 16);
    Serial.print("ID of 0xFF probably means a
bad address, a BMP 180 or BMP 085\n");
    Serial.print("ID of 0x56-0x58 represents a
BMP 280,\n");
    Serial.print("ID of 0x60 represents a BME
280.\n");
    Serial.print("ID of 0x61 represents a BME
680.\n");
    while (1)
      delay(10);
  }
```

```
    if (header3.from_node == 011) {    // If
data comes from Node 01 (worker)
      Serial.print("Data from worker: ");
      Serial.println(incomingData);  // print
the data
    }
  }
  //delay(1000);

  // Send to base

  int readData = DHT.read11(dhtPin);

  MyData sensorValue;
  sensorValue.temp = bmp.readTemperature();
  sensorValue.pressure = bmp.readPressure();
  sensorValue.hum = DHT.humidity;
  sensorValue.gas = analogRead(0);

  Serial.print(F("Temperature(*C) = "));
  Serial.println(sensorValue.temp);
  Serial.print(F("Pressure(Pa) = "));
  Serial.println(sensorValue.pressure);
  Serial.print(F("Humidity(%) = "));
  Serial.println(sensorValue.hum);
  Serial.print(F("Gas = "));
  Serial.println(sensorValue.gas);

  if (c == 0) {
    lcd_start = millis();
    c = c + 1;
  }
  lcd_end = millis();
  dt = lcd_end - lcd_start;
  if (dt > 2000) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print(F("Temp(*C)="));
    lcd.print(bmp.readTemperature());
    lcd.setCursor(0, 1);
    lcd.print(F("Pres(Pa)="));
    lcd.print(bmp.readPressure());
    lcd.setCursor(0, 2);
    lcd.print(F("Hum(%)="));
    lcd.print(DHT.humidity);
    lcd.setCursor(0, 3);
    lcd.print("Air=");
```

```
worker station

#include <Wire.h>
#include "MAX30105.h"
#include "heartRate.h"
#include <RF24Network.h>
#include <RF24.h>
#include <SPI.h>

#define led 5
#define buzzer 4

MAX30105 particleSensor;
RF24 radio(8, 10);               // nRF24L01
(CE,CSN)
RF24Network network(radio);      // Include the
radio in the network
const uint16_t worker = 011;  // Address of our
node in Octal format ( 04,031, etc)
const uint16_t sub_station = 01;    // Address
of the other node in Octal format
const uint16_t base = 00;

const byte RATE_SIZE = 4; //Increase this for
more averaging. 4 is good.
byte rates[RATE_SIZE]; //Array of heart rates
byte rateSpot = 0;
long lastBeat = 0; //Time at which the last beat
occurred

float beatsPerMinute;
int beatAvg;
long bpm_start;

void setup() {
  Serial.begin(115200);
  SPI.begin();
  radio.begin();
  network.begin(90, worker);  //(channel, node
address)
  radio.setDataRate(RF24_2MBPS);
  pinMode(led, OUTPUT);
  pinMode(buzzer, OUTPUT);
  if (!particleSensor.begin(Wire,
I2C_SPEED_FAST)) //Use default I2C port, 400kHz
speed
  {
    Serial.println("MAX30105 was not found.
Please check wiring/power. ");
    while (1);
  }
  Serial.println("Place your index finger on the
sensor with steady pressure.");
  bpm_start = millis();
  particleSensor.setup(); //Configure sensor
with default settings
  particleSensor.setPulseAmplitudeRed(0x0A);
//Turn Red LED to low to indicate sensor is
running
  particleSensor.setPulseAmplitudeGreen(0);
//Turn off Green LED
}

void loop() {
  int en = 0, c = 0;
  long bpm_end;
  const char text2[] = "Threshold Crossed for
worker1";
  network.update();
  //===== Receiving =====//
  while ( network.available() ) {     // Is
there any incoming data?
    RF24NetworkHeader header5;
    char text[32];

  network.read(header5, &text, sizeof(text)); //
Read the incoming data


//if (header5.from_node == 01) {
      //Serial.println(text);
      digitalWrite(led, HIGH);
      tone(buzzer, 1000);
      delay(1000);
      digitalWrite(led, LOW);
      noTone(buzzer);
    //}
  }
  long irValue = particleSensor.getIR();

  if (checkForBeat(irValue) == true)
  {
    //We sensed a beat!
    long delta = millis() - lastBeat;
    lastBeat = millis();

    beatsPerMinute = 60 / (delta / 1000.0);

    if (beatsPerMinute < 255 && beatsPerMinute >
20)
    {
      rates[rateSpot++] = (byte)beatsPerMinute;
//Store this reading in the array
      rateSpot %= RATE_SIZE; //Wrap variable

      //Take average of readings
      beatAvg = 0;
      for (byte x = 0 ; x < RATE_SIZE ; x++)
        beatAvg += rates[x];
      beatAvg /= RATE_SIZE;
    }
    //Serial.print(delta);
    //Serial.println();
  }
  Serial.print(", Avg BPM=");
  Serial.print(beatAvg);
  Serial.println();
  bpm_end = millis();
  if ((bpm_end - bpm_start) >= 30000)
    en = 1; //check bpm after 30s, time needed
for stable value

  if (irValue < 50000)
    beatAvg = 50;
  //Serial.print(" No finger?");
  //Serial.println();
  if (en) {
    if (beatAvg > 100 || beatAvg < 60) {
      //send alert to sub station
      RF24NetworkHeader header6(sub_station);
      bool ok = network.write(header6, &text2,
sizeof(text2)); // Send the data

      //send alert to base station
      RF24NetworkHeader header7(base);
      bool ok2 = network.write(header7, &text2,
sizeof(text2)); // Send the data
      Serial.print("gone");
      digitalWrite(led, HIGH);
      tone(buzzer, 1000);
      delay(1000);
      digitalWrite(led, LOW);
      noTone(buzzer);
    }
  }
}
```

Table: Source Code for the main program

4 Implementation

4.1 Description

This is the description for the design

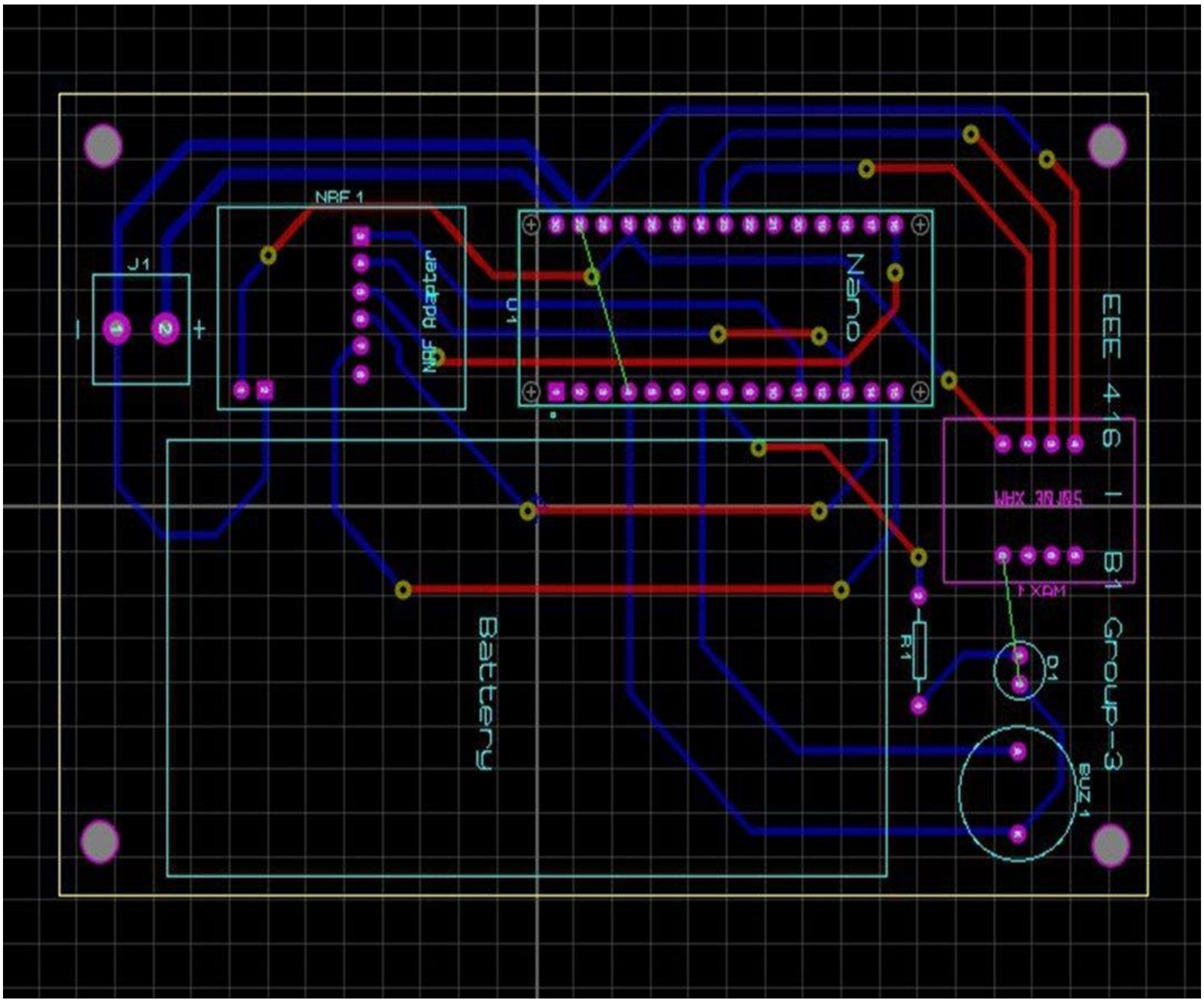
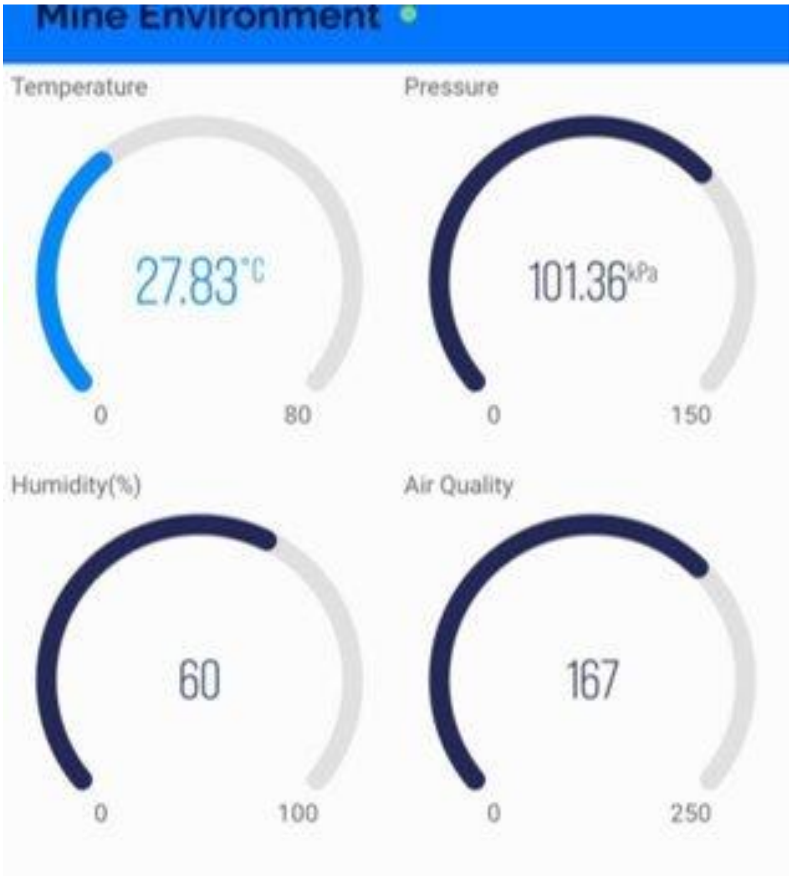


Figure4.1.1: PCB Layout

4.2 Results



Figure–4.2.1 Real time monitoring using web server

Fig-4.2.2: Safety alert in web server

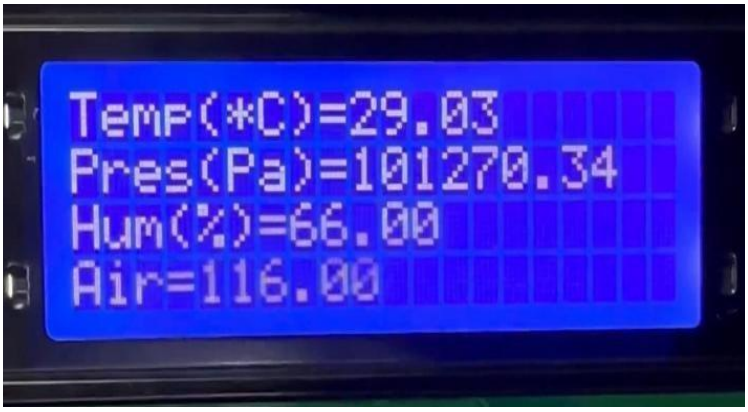


Fig-4.2.3: Environmental factors in substation

5 Design Analysis and Evaluation

5.1 Novelty

The novelty of this project lies in its innovative integration of IoT and machine learning technologies, creating a comprehensive framework for real-time monitoring and predictive analytics tailored for mining environments. By continuously monitoring environmental conditions, physiological indicators, and equipment status, the system enables timely intervention and proactive risk mitigation. This interdisciplinary approach, drawing upon expertise from electrical engineering, data science, and occupational health and safety, ensures a holistic solution to the complex challenges of mine worker safety. Addressing the unique characteristics of mining sites, such as confined spaces and hazardous gases, requires specialized solutions, making this project particularly innovative. Moreover, the inclusion of predictive analytics allows for the anticipation of potential hazards or equipment failures before they occur, further enhancing safety protocols. Overall, this project represents a pioneering effort in advancing safety practices in the mining industry through its comprehensive framework and integration of cutting-edge technologies.

5.2 Design Considerations

5.2.1 Considerations to public health and safety

Our project places paramount emphasis on ensuring the safety and well-being of both mine workers and the broader community. Through the deployment of our IoT-based monitoring system, our primary focus is on early detection and prevention of potential hazards present in mining environments. Utilizing real-time monitoring capabilities and predictive analytics, we aim to proactively mitigate risks to worker safety and public health. We are fully committed to adhering to all relevant regulations and standards, conducting comprehensive environmental impact assessments, and obtaining necessary permits to ensure compliance throughout the project lifecycle. Engaging with stakeholders, including local communities, regulatory bodies, and industry partners, is central to our approach. We actively solicit feedback, address concerns, and promote transparency and accountability in our operations. By continuously evaluating and managing risks, implementing robust cybersecurity measures, and fostering a culture of safety and continuous improvement, our goal is to establish a monitoring system that prioritizes public health and safety while supporting sustainable mining practices.

5.2.2 Considerations to environment

In addition to prioritizing public health and safety, our project is deeply committed to environmental stewardship throughout its lifecycle. We aim to minimize environmental impact by integrating eco-friendly practices, such as using energy-efficient sensors and reducing waste generation. Thorough environmental assessments guide our efforts to identify and mitigate potential risks. Moreover, we support sustainable resource management and conservation initiatives. By considering environmental factors in our project framework, we aim to achieve a balance between mining activities and ecological preservation, fostering a more sustainable future for all stakeholders.

5.2.3 Considerations to cultural and societal needs

Our project places significant importance on addressing cultural and societal needs alongside technical and operational aspects. Recognizing the diverse cultural and societal contexts in which mining operations take place, we strive to engage with local communities, indigenous groups, and other stakeholders to understand their unique perspectives, values, and concerns. By incorporating their input into our project planning and implementation processes, we aim to ensure that our initiatives align with and respect cultural traditions, social norms, and community aspirations. Additionally, we are committed to fostering positive relationships with communities impacted by mining activities, promoting inclusivity, diversity, and social cohesion. Through collaborative partnerships and meaningful dialogue, we seek to create mutually beneficial outcomes that support the well-being and resilience of all stakeholders involved.

5.3 Investigations

5.3.1 Literature Review

The literature review on IoT-based mine workers' health and safety monitoring systems reveals a multifaceted approach to enhancing safety in hazardous environments. Studies highlight the potential of IoT technologies to revolutionize monitoring practices through real-time environmental tracking, wearable sensors for physiological data collection, and predictive maintenance utilizing data analytics. Additionally, machine learning algorithms are identified as powerful tools for predicting equipment failures, while sensor technologies offer versatile solutions for monitoring various environmental parameters in mining operations. Wearable devices emerge as valuable tools for tracking workers' vital signs, with considerations for accuracy and user acceptance. Moreover, the integration of IoT and data analytics is recognized as a means to improve risk assessment and management in mines, offering insights from case studies and best practices. These reviews collectively provide a comprehensive overview of current technologies, methodologies, and challenges in mine safety monitoring, laying a foundation for further advancements in the field.

5.3.2 Experiment Design

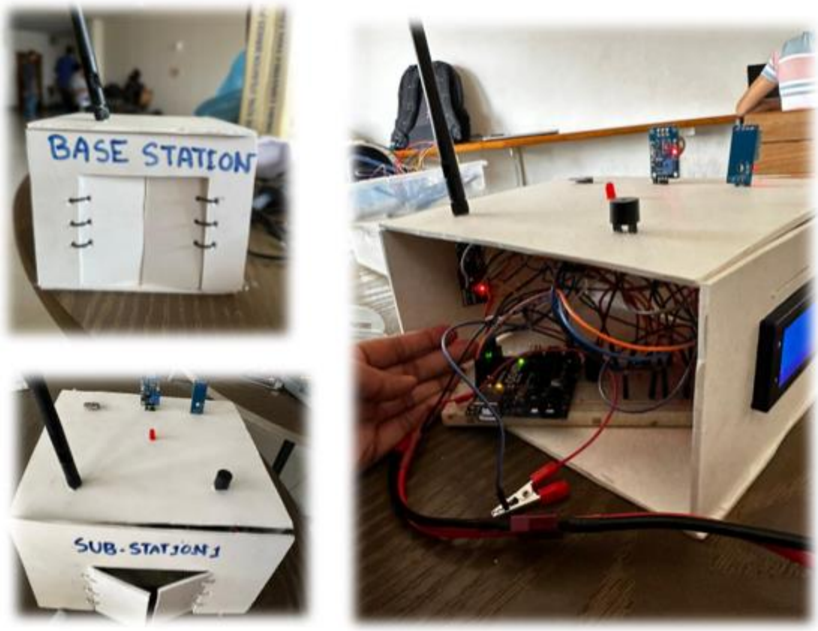


Figure-5.3.2.1: Experimental design for different station

Figure-5.3.2.2: PCB prototype for workers' safety device

5.4 Limitations of Tools

Despite facing limitations such as low-quality sensors, PCB boards, and budget constraints, our team remained dedicated to delivering a functional and reliable IoT-based mine workers health and safety monitoring system. Adapting to the challenges posed by these limitations, we focused on maximizing the efficiency and effectiveness of available resources. While the use of low-quality sensors and PCB boards presented obstacles in terms of data accuracy and device reliability, we implemented rigorous testing and calibration procedures to mitigate these issues to the best of our ability. Additionally, the shortage of budget necessitated careful prioritization of expenses, leading to creative solutions and cost-saving measures in various aspects of the project. In terms of PCB design, while constrained by simplicity, we leveraged available design tools and expertise to optimize functionality within the limitations. Despite these challenges, our team's perseverance and ingenuity enabled us to overcome obstacles and deliver a monitoring system that, while imperfect, still serves as a valuable tool for enhancing mine worker safety. Moving forward, we recognize the need for continued improvement and investment in higher-quality components and resources to further enhance the system's performance and reliability.

5.5 Impact Assessment

5.5.1 Assessment of Societal and Cultural Issues

We evaluate how the project impacts local communities and cultural heritage. We consider potential disruptions to traditional practices and social cohesion, as well as opportunities for positive engagement and community empowerment. By understanding and addressing these issues, we aim to ensure that our activities respect local values and contribute to the well-being of affected communities.

5.5.2 Assessment of Health and Safety Issues

Our focus is on evaluating the potential risks and benefits related to the health and safety of workers and the broader community. This involves identifying hazards associated with project activities, such as exposure to hazardous substances or physical dangers in the workplace. Additionally, the section assesses measures taken to mitigate these risks, such as implementing safety protocols, providing adequate training, and ensuring compliance with relevant regulations. By conducting a thorough assessment of health and safety issues, the project aims to prioritize the well-being of workers and minimize any adverse impacts on public health and safety.

5.5.3 Assessment of Legal Issues

We review the project's adherence to relevant laws, regulations, and legal requirements. This includes assessing compliance with health, safety, environmental, and labor regulations, as well as obtaining necessary permits and licenses. We also identify and address potential legal risks and liabilities, ensuring that the project operates within legal frameworks and minimizes any legal challenges.

5.6 Sustainability and Environmental Impact Evaluation

When examining the sustainability and environmental impact of our project, we undertake a comprehensive assessment to understand its implications for nature and long-term viability. This entails evaluating the potential consequences on natural resources, ecosystems, and the well-being of local communities. We scrutinize the various activities involved in the project to identify potential risks, such as habitat disruption, air or water pollution, and depletion of resources. Moreover, we explore strategies to mitigate these impacts, emphasizing the adoption of eco-friendly technologies, sustainable practices, and responsible resource management. This involves considering alternatives and implementing measures that minimize harm to the environment while maximizing positive outcomes. Additionally, we investigate opportunities for promoting biodiversity conservation, restoring degraded habitats, and fostering resilience in ecosystems. By conducting a thorough evaluation of sustainability and environmental impact, we aim to ensure that our project aligns with principles of environmental stewardship, contributes to conservation efforts, and supports the well-being of both nature and communities in the areas where we operate.

5.7 Ethical Issued

Addressing Ethical Issue we practiced in the Project:

1. **Data Privacy and Security:** We implemented robust measures to protect the privacy and security of personal data collected from mine workers through IoT devices. This included encryption, anonymization, and restricted access to sensitive information.

2. **Informed Consent:** We obtained informed consent from workers regarding the collection and use of their data, ensuring transparency about how their information would be utilized.

3. **Community Engagement:** We engaged in meaningful dialogue with local communities and indigenous groups to understand their concerns and perspectives. We sought their input and feedback, respecting their rights and cultural heritage throughout the project.

4. **Fair Labor Practices:** We prioritized fair labor practices, ensuring safe working conditions, fair wages, and equal opportunities for all workers involved in project implementation.

By adhering to these ethical principles and proactively addressing ethical challenges, we strive to conduct our project in a responsible, equitable, and respectful manner, fostering trust and collaboration among all stakeholders.

6 Reflection on Individual and Teamwork

6.1 Mode of Teamwork

We utilized both offline and online methods to ensure the timely completion of the project. Initially, we divided our team into two groups. The first group focused on developing various input-taking devices, consolidating their functionalities, and compiling progress reports and presentations. Meanwhile, the second group was tasked with creating the networking infrastructure for the project.
This approach allowed us to efficiently manage the workload and streamline the project's progress. By dividing tasks into specialized groups, we were able to leverage individual expertise and work concurrently on different aspects of the project. The first group's responsibilities included designing and developing sensors, data collection devices, and interfaces, ensuring compatibility and functionality across all components. They also documented their progress and findings, facilitating communication and transparency within the team. On the other hand, the second group focused on establishing the networking framework necessary for data transmission, storage, and communication between devices. This involved setting up servers, configuring networking protocols, and ensuring seamless connectivity and data flow. By coordinating efforts between the two groups, we maintained a cohesive approach towards achieving project milestones and delivering a comprehensive solution.

6.2Diversity Statement of Team

Our Diversity Statement reflects our team's belief in treating everyone equally and valuing their differences. We have team members from various backgrounds, which makes our team stronger. We think having different perspectives helps us come up with better ideas. We want everyone on our team to feel respected and included no matter who they are. We encourage everyone to share their thoughts and listen to each other. Our goal is to create a friendly and supportive team where everyone can do their best work.

6.3 Logbook of Project Implementation

7 Communication

7.1 Executive Summary

<u>New Project Revolutionizes Safety in Mines!</u>

Our latest project introduces innovative technology to keep mine workers safe. Using smart devices and advanced software, we monitor workers' health and surroundings in real-time. With easy-to-use sensors, we track temperature, gas levels, and workers' vital signs, helping to prevent accidents and ensure quick response in emergencies. Our team prioritizes safety and inclusivity, making sure everyone's voice is heard. Together, we're making mining safer and more efficient for everyone involved. Join us in this exciting journey towards a safer future!

Contact,
Mobile: 01840558528

7.2 User Manual

<u>User Manual: Easy Guide for Keeping Mine Workers Safe</u>

Welcome to our easy guide for the IoT-Based Mine Workers Health and Safety Monitoring System! This manual will help you set up and use the system to keep mine workers safe in risky places.

1. What's Inside:
- The system has special devices, sensors, and a main network.
- These devices have sensors to watch the air and how workers are doing.
- The sensors send what they see to the main network for checking.

2. Setting Up:
- Carefully open the box with the devices and sensors.
- Put the sensors where they're supposed to go and make sure they're set up right.
- Connect the devices to power and make sure they can talk to the network.

3. How It Works:
- Turn on the devices and make sure they're talking to the network.
- Look at the main screen to see what's happening with the air and the workers.
- Decide on levels for things like temperature and heart rate. If they go too high or low, the system will tell you.

4. Taking Care of It:
- Look at the sensors and devices often to make sure they're not broken.
- Clean them if they get dirty so they keep working right.
- Update the software sometimes to make sure everything works well and stays safe.

5. Staying Safe:
- Always follow the safety rules when you're using the system.
- Don't change anything on the devices unless you know what you're doing.
- Make sure anyone using the system knows how to do it safely.

6. Fixing Problems:
- Check the manual for help if something isn't working right.
- If you still need help, call the support team for more assistance.

7. Need Help?
- If you have questions or problems, contact our support team at [email: minersbd@gmail.com].

Thank you for choosing our system to keep mine workers safe. We're here to make sure everyone stays safe and sound while they're working hard.

8 Project Management and Cost Analysis

8.1 Bill of Materials

COST ANALYSIS			
Stations	**No**	**Components**	**Price (Tk)**
A. **Base Station**	A1	NRF24L01+PA+LNA module	225
	A2	NRF module adapter	80
	A3	ESP32	450
	A4	Micro USB cable	100
	A5	Breadboard Mini	30
B. **Sub Station**	B1	Arduino Uno	800
	B2	LCD Display (20×4) + I2C	500
	B3	BMP280	150
	B4	NRF24L01+PA+LNA module	225
	B5	NRF module adapter	80
	B6	MQ135	150
	B7	DHT11	135
	B8	LED+RES+BUZZER	15
	B9	Battery	2000
	B10	Buck module	55
C. **Workers' End**	C1	NRF24L01+PA+LNA module	225
	C2	NRF module adapter	80
	C3	LED+RES+BUZZER	15
	C4	MAX30102	390
	C5	Arduino Nano	380
	C6	Battery + Casing	140
	C7	PCB + Soldering	500

Table-8.1.1: Cost of components

8.2Calculation of Per Unit Cost of Prototype

Stations	**Price per unit Prototype (Tk)**
A. Base Station	885
B. Sub-Station	4055
C. Workers' End	1730
Total Cost per unit Prototype	=6670

Table-8.2.2: Cost of each substation

8.3Calculation of Per Unit Cost of Mass-Produced Unit

As the project transitions to mass-production, there is potential for a slight reduction in the per unit cost. However, accurately determining the total cost of installing our device hinges upon several factors. Foremost among these considerations is the size of the mine, as well as the number of substations present within it. Additionally, the total cost depends on the workforce size within the mine. Without precise information regarding these dimensions, calculating the comprehensive cost remains challenging. Each mine's unique layout and operational requirements necessitate a tailored approach to cost estimation. As such, a thorough assessment of the mine's specifications and operational parameters is essential for accurate cost projections. Despite the potential for economies of scale in mass-production, the variability inherent in mine dimensions and workforce dynamics underscores the importance of detailed planning and assessment in determining the total installation cost of our device.

8.4 Timeline of Project Implementation

Primarily we took 14 weeks for this project. But for the commercial production we can complete the task within 4 weeks for small amount of volume.

9 Future Work

Here are some future work proposals,

1. Enhanced Sensor Capabilities: Develop advanced sensors with increased accuracy and additional functionalities to monitor a wider range of parameters, such as air quality, noise levels, and ergonomic factors.

2. Integration of AI and Machine Learning: Explore the integration of artificial intelligence (AI) and machine learning algorithms to enhance predictive analytics capabilities, enabling more accurate forecasting of safety hazards and proactive risk mitigation strategies.

3. Mobile Application Development: Create a user-friendly mobile application for remote monitoring and management of the system, allowing stakeholders to access real-time data and receive alerts on their smartphones or tablets.

4. Expansion to Other Industries: Investigate opportunities to adapt the monitoring system for use in other high-risk industries beyond mining, such as construction, manufacturing, or agriculture, to improve safety and efficiency across various sectors.

5. Long-Term Data Analysis: Establish long-term data analysis initiatives to identify trends, patterns, and correlations in the collected data, providing valuable insights for improving safety protocols, optimizing workflows, and enhancing overall operational efficiency.

6. Community Engagement and Education: Implement outreach programs and educational initiatives to raise awareness about the importance of health and safety in the workplace, empower workers with knowledge and skills to identify and address safety hazards, and foster a culture of safety within the organization and the broader community.

7. Collaborative Research and Development: Collaborate with industry partners, research institutions, and regulatory bodies to further advance the state-of-the-art in health and safety monitoring technologies, share best practices, and contribute to the development of industry standards and guidelines.

By outlining potential future directions for the project, the "Future Work" section demonstrates a forward-looking approach and underscores the project's commitment to continuous improvement and innovation.

10 References

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